

Steroidal Sapogenins XXV.*

Survey of Plants for Steroidal Sapogenins and Other Constituents

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Number VII in this series covered the survey of the first 1000 plant accessions (1), and number XII the second 1000 (2). The present report is a continuation of these and covers the third 1000. Paper VII should be consulted for background, methods, and objectives. The data include the kinds and amounts of steroidal sapogenins found, and the results of qualitative tests for saponins, flavonoids, alkaloids, tannins, and unsaturated sterols. There are 954 lots of plant material, representing 606 identified species, 160 lots identified as to genus only, 348 genera, and 96 families. There are 21 families, 225 genera, and 513 species not found in the first two lists. To date, one or more species in 693 genera, representing 157 families, have been analyzed. There is no published chemical information on about 50 per cent of the species examined.

BECAUSE of an increased interest in hecogenin as a possible source of cortisone, a greater emphasis was placed on collecting as many species of agave as was possible. These collections were obtained by Gentry mainly from northern Mexico especially in Baja California. Besides random collecting of species of agave, large repeat samples were obtained of those that showed promise of a high yield of sapogenins in preliminary tests.

Besides the large and intensive collections of agaves, yuccas, dioscoreas, and other plants in Mexico were a number of miscellaneous species for testing that were provided by the various plant introduction gardens of the Section of Plant Introduction, located at Coconut Grove, Fla.; Glenn Dale, Md.; and Chico, Calif. A few additional collections of native species from various regions were also obtained for analysis.

RESULTS

In the case of numbers VII and XII in this series, covering the results of the first and second 1000 accessions, the complete tabulated results were published as supplements in processed form (3, 4). The same has been done with the present third 1000 accessions. The supplement (5) may be obtained by requesting ARS-73-4 from the Eastern Utilization Research Branch, United States Department of Agriculture, Philadelphia 18, Pa.

The main objective of this screening of large numbers of plants is to find steroidal sapogenins which, because of their chemical nature and accessible oc-

currence, could be suitable starting materials for cortisone synthesis. A summary of the steroidal sapogenins found in the present series, and their occurrence by species, is given in Table I. A brief summary of all findings follows.

The occurrence of saponins in general, as indicated by the hemolysis test, varied considerably from one group of plants to another. In agave, dioscorea, and yucca, 77, 60, and 95% of the accessions gave positive tests; in the plants outside of these groups, 27%; and in all lots, 40%. In families represented by 26 to 116 species the variation was *Bignoniaceae*, 8%; *Palmae*, 30%; *Leguminosae*, 34%; *Apocynaceae*, 50%.

Some of the outstanding conclusions derived from the sapogenin data are as follows: as in the previous reports in this series (1-4), dioscorea tubers or roots contained the highest total sapogenin content. Of identified species, *Dioscorea composita* was outstanding, with four lots from the Veracruz region containing 3.3, 3.5, 6.9, and 4.6% sapogenin, almost exclusively diosgenin. However, many unidentified species were quite high, ten lots from Guatemala containing from 2.1 to 6.2%. Several rare sapogenins, first discovered by Marker and co-workers (6) in dioscorea, were found in our collections for the first time. Thus yamogenin was found in *Dioscorea mexicana* as well as in several unidentified *Dioscorea* spp. Unfortunately, this sapogenin could not be cleanly separated from diosgenin. However, infrared assay indicated that in some cases as much as 50% of the total sapogenin was yamogenin. Pennogenin was found in 0.6% quantity mixed with 1.9% diosgenin in a *Dioscorea* spp. from Guatemala. Marker, *et al.* (6), report pennogenin only in beth root (probably *Trillium erectum*).

Turning to other sapogenins, 1.2% of chlorogenin was found in *Agave schottii* leaves, a new high for this sapogenin. Gitogenin, 3.2%, was found in crowns of *Manfreda* spp. from Oaxaca, Mexico, constituting the highest concentration of this sapogenin on record. Hecogenin was found in a number of agave species found in Baja California, always in mixtures and not in outstanding yield. Markogenin and sarsasapogenin, respectively 0.8% and 2.5%, were found in record quantities in capsules of *Yucca schidigera* from San Augustin, B. C., Mexico.

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TABLE I.—OCCURRENCE OF THE VARIOUS SAPOGENINS BY SPECIES

TABLE 1.—OCCURRENCE OF THE VARIOUS GENINS							
Species	No. of Samples	Genin Content		Species	No. of Samples	Genin Content	
		M. F. B., %	Min. Max.			M. F. B., %	Min. Max.
Chlorogenin							
<i>Agave colorata</i>	1	..	0.09	<i>Agave toumeyana</i>	3	0.4	0.7
<i>Agave fourcroydes</i>	1	..	Tr.	<i>Agave vexans</i>	1	..	0.3
<i>Agave schottii</i>	2	0.6	1.2	<i>Agave yaquiana</i>	1	..	Tr.
<i>Agave shrevei</i>	1	..	0.1	<i>Agave sp.</i>	8	0.1	0.7
<i>Agave yaquiana</i>	1	..	Tr.	<i>Yucca gloriosa</i>	1	..	0.1
<i>Agave sp.</i>	1	..	0.4				
<i>Yucca freemanii</i>	1	..	0.04	Kammogenin			
9-Dehydrohecogenin				<i>Yucca carnerosana</i>	1	..	0.5
<i>Agave expansa</i>	1	..	Tr.				
<i>Agave goldmaniana</i>	2	0.06	0.1	Manogenin			
<i>Agave sobria</i>	1	..	0.1	<i>Agave goldmaniana</i>	3	Tr.	0.1
<i>Agave sp.</i>	2	0.2	0.6	<i>Agave margaritae</i>	1	..	Tr.
9-Dehydromanogenin				<i>Agave nelsonii</i>	3	0.1	0.2
<i>Agave goldmaniana</i>	2	..	Tr.	<i>Agave owenii</i>	1	..	Tr.
<i>Agave margaritae</i>	1	..	Tr.	<i>Agave sobria</i>	1	..	0.6
<i>Agave nelsonii</i>	3	..	Tr.	<i>Agave toumeyana</i>	3	Tr.	0.3
<i>Agave owenii</i>	1	..	Tr.	<i>Agave sp.</i>	4	..	Tr.
<i>Agave sobria</i>	1	..	0.6	<i>Yucca gloriosa</i>	1	..	0.3
<i>Agave toumeyana</i>	1	..	Tr.				
<i>Agave sp.</i>	2	..	0.1	Markogenin			
Diosgenin				<i>Yucca schidigera</i>	2	0.6	0.7
<i>Dioscorea composita</i>	5	2.6	6.9				
<i>Dioscorea mexicana</i>	3	0.3	0.8	Pennogenin			
<i>Dioscorea quaternata</i>	2	0.5	1.1	<i>Dioscorea sp.</i>	1	..	0.6
<i>Dioscorea villosa</i>	1	..	1.0				
<i>Dioscorea sp.</i>	17	2.1	6.2	Sarsasapogenin			
<i>Pseudophoenix insignis</i>	2	0.8	1.5	<i>Yucca schidigera</i>	3	0.3	2.6
Gitogenin				<i>Yucca sp.</i>	3	0.3	1.4
<i>Agave desertii</i>	1	..	0.1				
<i>Agave goldmaniana</i>	1	..	0.1	Smilagenin			
<i>Agave nelsonii</i>	1	..	0.1	<i>Agave grandidentata</i>	1	..	1.2
<i>Agave owenii</i>	2	..	Tr.	<i>Agave lecheguilla</i>	2	0.2	0.6
<i>Agave roseana</i>	1	..	0.1	<i>Agave mayoensis</i>	1	..	1.7
<i>Agave schidigera</i>	1	..	1.0	<i>Agave nelsonii</i>	1	..	0.2
<i>Agave sobria</i>	1	..	Tr.	<i>Agave sp.</i>	2	0.2	0.3
<i>Agave toumeyana</i>	3	0.2	0.3				
<i>Agave sp.</i>	2	Tr.	0.3	Tigogenin			
<i>Manfreda sp.</i>	1	..	3.2	<i>Agave colorata</i>	1	..	Tr.
<i>Yucca carnerosana</i>	1	..	0.1	<i>Agave desertii</i>	1	..	0.6
<i>Yucca peninsularis</i>	4	0.1	0.5	<i>Agave expansa</i>	1	..	Tr.
Hecogenin				<i>Agave fourcroydes</i>	4	Tr.	0.1
<i>Agave desertii</i>	1	..	0.2	<i>Agave goldmaniana</i>	4	Tr.	0.2
<i>Agave expansa</i>	1	..	Tr.	<i>Agave hartmannii</i>	1	..	0.1
<i>Agave fourcroydes</i>	4	Tr.	0.4	<i>Agave nelsonii</i>	4	0.1	0.7
<i>Agave goldmaniana</i>	5	Tr.	1.0	<i>Agave owenii</i>	3	Tr.	0.2
<i>Agave hartmannii</i>	1	..	0.1	<i>Agave roseana</i>	2	0.9	2.2
<i>Agave margaritae</i>	1	..	0.2	<i>Agave schottii</i>	1	..	0.3
<i>Agave morrisii</i>	1	..	0.5	<i>Agave shrevei</i>	1	..	0.3
<i>Agave nelsonii</i>	4	Tr.	0.7	<i>Agave sisalana</i>	1	..	0.1
<i>Agave owenii</i>	2	Tr.	0.1	<i>Agave sobria</i>	2	0.6	0.7
<i>Agave roseana</i>	1	..	0.3	<i>Agave yaquiana</i>	2	..	Tr.
<i>Agave shrevei</i>	1	..	Tr.	<i>Agave sp.</i>	5	0.2	0.4
<i>Agave sisalana</i>	1	..	0.1	<i>Yucca freemanii</i>	1	..	0.4
<i>Agave sobria</i>	2	Tr.	0.8	<i>Yucca gloriosa</i>	1	..	Tr.
				<i>Yucca peninsularis</i>	5	0.4	1.8
				Yamogenin			
				<i>Dioscorea composita</i>	1	..	0.1
				<i>Dioscorea mexicana</i>	2	0.3	0.6
				<i>Dioscorea sp.</i>	3	Tr.	1.2

The value for sarsasapogenin is exceeded only by a result previously reported for *Y. schidigera* leaves (4). Smilagenin, 1.7%, was found in leaves of *Agave mayoensis* from San Bernardo, Sonora, Mexico, again a record figure. Another record value was 2.2% tigogenin found in *Agave roseana* from Punta Frailes, B. C., Mexico.

Although steroidal sapogenins occur predominantly in agave, dioscorea, and yucca, they have

been found in 85 species in 56 other genera. The present list contains four new species—*Tristania conferta* (Myrtaceae), *Chamaedorea erumpens*, and *Pseudophoenix insignis* (Palmae), *Cestrum nocturnum* (Solanaceae).

The biogenetical relationships of the sapogenins found during this survey were essentially the same as those described in the previous surveys (1, 2).

Flavonoids were scarce in this list. Only 9

double plus and no triple plus tests were obtained. However, 8 of these species have not been known before to contain flavonoids.

As to alkaloids, of the 11 species which gave a double or triple plus test the following are the first of record: *Vinca minor* (Apocynaceae); *Tecoma gaudichaudii* (Bignoniaceae); *Cephalotaxus* sp. (Cephalotaxaceae); *Albizia polyphylla*, *Cassia spectabilis*, *Samanea saman*, and *Trachylobium hornemannianum* (Leguminosae); *Pinus sabiniana* (Pinaceae).

Tannins were frequent and abundant in *Anacardiaceae*, *Combretaceae*, and *Myrtaceae*. Triple plus tests were obtained in 35 species in 18 other families.

As in the second 1000 accessions, unsaturated sterols were frequent and abundant in *Bignoniaceae*, *Combretaceae*, *Leguminosae*, *Myrtaceae*, *Palmae*, *Pinaceae*, *Polygonaceae*, *Rosaceae*, and *Oleaceae*.

SUMMARY

This is a report of the chemical examination of the third 1000 plant samples received in a survey for steroidal sapogenins. Data are given for 954 lots of plant material, representing 606 identified species, 160 identified as to genus only, 348 genera, and 96 families. There is no previously published chemical information on about 50 per cent of the species.

Quantitative data are given for the occurrence of 14 steroidal sapogenins. These were found almost exclusively in agave, dioscorea, and yucca but also in four new species outside these genera.

Results of qualitative tests are given for the occurrence of the following groups of constituents: saponins, flavonoids, alkaloids, tannins, and unsaturated sterols. New species of record are 8 for flavonoids and 8 for alkaloids.

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